PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application No.:	10/664,503
Filing Date:	September 17, 2003
Appellant:	Paul Taichiang Yu
Group Art Unit:	1795
Examiner:	Imran Akram
Title:	WGS REACTOR INCORPORATED WITH CATALYZED HEAT EXCHANGER FOR WGS REACTOR VOLUME REDUCTION
Attorney Docket:	GP-302212

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APPELLANT'S APPEAL BRIEF

This is Appellant's Appeal Brief filed in accordance with 37 CFR §41.37 appealing the Examiner's Final Office Action mailed October 29, 2008. Appellant's Notice of Appeal, pursuant to 37 CFR §41.31, was filed on January 28, 2009. The Appeal Brief fee pursuant to 37 CFR §41.20(b)(2) is included herewith.

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I. Real Party in Interest

The real party in interest for this appeal is the General Motors Corporation of Detroit, Michigan, the assignee of this application.

II. Related Appeals and Interferences

There are no related appeals or interferences that would affect the Board's decision on this appeal.

III. Status of the Claims

Claims 1-28 are pending. Claims 11-19 and 24-28 have been withdrawn as being directed to a non-elected invention. Claims 1-10 and 20-23 stand rejected. Claims 1-10 and 20-23 are on appeal. No claim has been cancelled. No claim has been objected to. No claim has been allowed.

IV. Status of Amendments

All amendments have been entered.

V. Summary of Claimed Subject Matter

Independent claim 1 claims a water-gas shift reactor assembly, such as water-gas shift reactor assembly 48 shown in figure 2 and discussed at page 7, lines 1-14. The water-gas shift reactor assembly 48 includes a first stage water-gas shift reactor 52 receiving a reformate gas, a heat exchanger 60 receiving the reformate gas from the first stage reactor 52 and a second stage water-gas shift reactor 68 receiving the cooled reformate gas from the heat exchanger 60. Each of the first stage reactor 52, the heat exchanger 60 and the second stage reactor 68 include a catalyst that converts carbon monoxide and water to carbon dioxide and hydrogen, see paragraph [0024], page 7,

lines 15-23. The water-gas shift reactor assembly 48 is a single unit where the first stage water-gas shift reactor 52 is coupled to an inlet end of the heat exchanger 60 by a connector 56 and the second stage water-gas shift reactor 68 is coupled to an outlet end of the heat exchanger 60 by a connector 70, see paragraph [0024], page 7, lines 15-23.

Independent claim 20 claims a fuel processing system, such as fuel processing system 10 shown in figure 1 and discussed in paragraphs [0020]-[0032]. The fuel processor system 10 generates a hydrogen rich reformate gas to be used in a fuel cell engine. The fuel processing system 10 includes a primary reactor 14 that receives a liquid hydrocarbon fuel on line 16 and generates a reformate gas including hydrogen and carbon monoxide on line 44, see page 6, lines 1-13. The fuel processing system 10 also includes a first heat exchanger 20 that receives the reformate gas from the primary reactor 14 and cools the reformate gas, see page 6, lines 3-5. The fuel processing system 10 also includes a water-gas shift reactor assembly 48 that receives the reformate gas from the first heat exchanger 20, see paragraph [0023], page 7, lines 1-14 and figure 2. The water-gas shift reactor assembly 48 includes a first stage water-gas shift reactor 52 receiving the cooled reformate gas from the first heat exchanger 20, a second heat exchanger 60 receiving the reformate gas from the first stage reactor 52 and a second stage water-gas shift reactor 68 receiving the cooled reformate gas from the second heat exchanger 60. Each of the first stage reactor 52, the second heat exchanger 60 and the second stage reactor 68 include a catalyst that converts carbon monoxide and water to carbon dioxide and hydrogen, see paragraph [0024], page 7, lines 15-23. The water-gas shift reactor assembly 48 is a single unit where the first stage water-gas shift reactor 52 is coupled to an inlet end of the second heat exchanger 60 by a connector 56 and the second stage water-gas shift reactor 68 is coupled to an

outlet end of the second heat exchanger 60 by a connector 70, see paragraph [0024], page 7, lines 15-23. The fuel processing system 10 also includes a third heat exchanger 82 that receives the reformate gas from the second stage reactor, see paragraph [0031], page 10, lines 1-7, and a preferential oxide reactor 84 that receives the cooled reformate gas from the third heat exchanger 82, where the preferential oxide reactor 84 includes a catalyst that selectively oxidizes carbon monoxide to carbon dioxide in the reformate gas, see paragraph [0031], page 10, lines 1-7.

VI. Grounds of Rejection to be Reviewed on Appeal

Whether claims 1, 3-10, 20, 21 and 23 should be rejected under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent Publication No. 2002/0168307 to Seaba et al. (hereinafter Seaba);

Whether claims 2 and 22 should be rejected under 35 USC §103(a) as being unpatentable over Seaba in view of U.S. Patent Publication No. 2004/0089438 to Valensa (hereinafter Valensa); and

Whether claims 1, 4-6 and 8-10 should be rejected under 35 USC §103(a) as being unpatentable over U.S. Patent No. 5,221,524 issued to Eguchi (hereinafter Eguchi) in view of U.S. Patent No. 4,288,346 issued to Hunter (hereinafter Hunter).

VII. Argument

A. Independent claims 1 and 20 are not obvious in view of Seaba

1. Independent claims 1 and 20

Independent claims 1 and 20 specifically state that the water-gas shift reactor assembly includes a first stage water-gas shift reactor coupled to an inlet end of a heat exchanger by a first connector and a second stage water-gas shift reactor coupled to an

outlet end of the heat exchanger by a second connector so that the water gas shift reactor, the heat exchanger and the second stage water-gas shift reactor are combined as a single unit.

2. Seaba

Seaba discloses a fuel processor for processing hydrocarbon fuels, as shown in figure 1. The Seaba fuel processor includes a number of fuel processing elements that are known in these types of systems for providing hydrogen gas to a fuel cell stack 68. These elements include in order of hydrogen reformate gas flow, a heat exchanger 30, a steam reformer 34, a heat exchanger 38, a water-gas shift (WGS) reactor 42, a heat exchanger 46, a WGS reactor 50, a heat exchanger 54 and a preferential oxidation reactor 60. Each of these elements is a separate element in the fuel processor disclosed by Seaba. The Examiner has separated the WGS reactor 42, the heat exchanger 46 and the WGS reactor 50 from the string of elements as being applicable to Appellant's claimed water-gas shift reactor assembly. Seaba talks about a specific heat exchanger 300 shown in figure 1b including volumes 301 and 302 on opposite sides of a separator 303. Figure 3a shows a wavy plate separator including a wavy plate 320 having a catalyst material 324, which apparently can be used as the heat exchanger 300.

3. Discussion

Appellant respectfully submits that Seaba cannot properly make obvious independent claims 1 and 20 because the WGS reactor 42 and the WGS reactor 50 are not coupled to opposite ends of the heat exchanger 46 by connectors, where the WGS reactor 42, the heat exchanger 46 and the WGS reactor 50 are combined as a single

unit. Clearly, from the discussion in Seaba, each of the WGS reactor 42, the heat exchanger 46 and the WGS reactor 50 are separate devices, as shown in figure 1.

The Examiner states on page 4 of the Final Office Action that:

> Seaba does not disclose, however, that the components are integral. This is a well-known means in the art to increase heat efficiency, however. It would have been obvious to one having ordinary skill in the art at the time of invention to make integral the shift reactors and heat exchanger of Seaba as the shift reactors surround the heat exchanger and integrating them would afford the invention better thermal efficiency. See MPEP 2144.04VB.

MPEP 2144.04VB discusses two cases, namely, *In re Larson*, 340 F.2d 965, 144 USPQ 347 (CCPA 1965) and *Schenk v. Norton Corp.*, 713 F.2d 782, 218 USPQ 698 (Fed. Cir. 1983), that discuss the patentability of claims that include an integral combination of elements already existing in the prior art. The court in *In re Larson* held the claims unpatentable as being merely a matter of obvious engineering choice. However, the court in *Schenk v. Norton Corp.* found the claims to be patentable because the integral reconstruction provided a need not found in the prior art, namely, "mechanisms to dampen resonance."

Appellant respectfully submits that claims 1 and 20 including the combination of a first water-gas shift reactor coupled to an inlet end of a heat exchanger by a connector and a second water-gas shift reactor coupled to an outlet end of the heat exchanger by a connector provides more than merely a design choice and provides significant advantages over fuel processing systems having individual elements known in the prior art. For example, the engineering and design that would need to go into coupling the first water-gas shift reactor to the inlet end of the heat exchanger using a connector and coupling the second water-gas shift reactor to the outlet end of the heat exchanger is far greater than simply connecting existing water-gas shift reactors to existing heat

exchangers. Appellant respectfully submits that the water-gas shift reactor 42, the heat exchanger 46 and the water gas shift reactor 50 in Seaba just don't snap together.

Appellant further submits that the combined unit of two water-gas shift reactors separated by a heat exchanger as claimed provides a number of advantages, including compact design, lower weight, more efficient catalyst use, etc., than those gas reforming systems known in the art can provide. Paragraph [0011] of Appellant's specification talks about reducing the size and mass of fuel processing systems to satisfy vehicle weight and size requirements. Thus, Appellant submits that the combination of elements in the water-gas shift reactor assembly as claimed is more than just a matter of design choice. By combining the first and second stage water-gas shift reactors and the heat exchanger into a single unit, various housing walls, plumbing, structural elements, etc. can be included as parts of multiple devices so that the size and weight of the elements that make up the water-gas shift reactor assembly can be reduced over known hydrogen gas reforming systems, where the water-gas shift reactors and heat exchangers are separate units. Appellant respectfully submits that there is no teaching in Seaba of combining the water-gas shift reactor 42, the heat exchanger 46 and the water-gas shift reactor 50 as a single unit, or that it is even possible to combine these devices into a single unit.

4. Dependent claims 3-10, 21 and 23

Appellant respectfully submits that certain of the dependent claims include specific temperatures of the reformate gas as it travels through the claimed water-gas shift reactor assembly that are not taught or suggested be Seaba. Appellant submits that because Seaba does not teach integrating water-gas shift reactors and a heat exchanger as a single unit, as discussed above, the various operating temperatures of

the reactors and heat exchangers of these dependent claims can also not be made obvious by Seaba.

B. Claims 2 and 22 are not obvious in view of Seaba, Valensa and Applicant's admitted prior art

Valensa discloses a heat exchanger, but does not teach or suggest a heat exchanger of a particular type that can be used in an integrated assembly including two water-gas shift reactors. Therefore, Appellant respectfully submits that Valensa cannot provide the teaching missing from Seaba to make dependent claims 2 and 22 obvious.

C. Claims 1, 4-6 and 8-10 are not obvious in view of Eguchi and Hunter

Eguchi discloses a system for producing hydrogen from a reformate gas 3. The Examiner has directed Appellant's attention to figure 3A of Eguchi as showing a high temperature shift converter or reactor 1a, a heat exchanger 5 and a low temperature shift converter or reactor 7. As with Seaba above, the reactor 1a, the heat exchanger 5 and the reactor 7 are separate units. Further, there is no teaching in Eguchi that these elements can be combined using connectors into a single unit. Therefore, Appellant submits that Eguchi fails to make obvious Appellant's independent claim 1 for the same reasons as Seaba.

The Examiner states on page 7 of the final Office Action that the reactor 1a is coupled to an inlet end of the heat exchanger 5 and that the reactor 7 is coupled to the outlet end of the heat exchanger 5. Appellant respectfully submits that the reactor 1a is coupled to the heat exchanger through a gas 4, see column 1, line 44 of Eguchi, and that the reactor 7 is coupled to the heat exchanger 5 by a cooled gas 6, see column 1, line 52 of Eguchi. Appellant respectfully submits that Eguchi clearly does not teach or suggest that the reactor 1a is coupled to the heat exchanger 5 by a connector and that

the reactor 7 is coupled to an outlet end of the heat exchanger 5 by a connector, where the reactors 1a and 7 and the heat exchanger 5 are combined as a single unit. Therefore, as with the Seaba combination of separate reactors and heat exchangers, Eguchi also does not teach a single unit comprised of two water-gas shift reactors and a heat exchanger, as claimed.

Hunter discloses a catalyst for a catalytic heat exchanger. It is believed that the Examiner is relying on Hunter to teach providing a catalyst within a heat exchanger. Appellant respectfully submits that Hunter does not teach a water-gas shift reactor assembly including water-gas shift reactors and a heat exchanger combined as a single unit, as discussed above. Therefore, Hunter fails to provide the teaching missing from Eguchi to make Applicant's claimed invention obvious.

VIII. Conclusion

Appellant respectfully submits that claims 1, 3-10, 20, 21 and 23 are not obvious in view Seaba, claims 2 and 22 are not obvious in view of Seaba, Valensa and Appellant's admitted prior art and claims 1, 4-6 and 8-10 are not obvious in view of Eguchi and Hunter. It is therefore respectfully requested that the Examiner's §103 rejections be reversed.

Respectfully submitted,

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CLAIMS APPENDIX

COPY OF CLAIMS INVOLVED IN THE APPEAL

1. A water-gas shift reactor system comprising:

a first stage water-gas shift reactor receiving a reformate gas, said first stage reactor including a catalyst that converts carbon monoxide and water to carbon dioxide and hydrogen;

a heat exchanger receiving the reformate gas from the first stage reactor, said heat exchanger cooling the reformate gas, said heat exchanger including a catalyst that converts carbon monoxide and water to carbon dioxide and hydrogen, said first stage water-gas shift reactor being coupled to an inlet end of the heat exchanger by a first connector; and

a second stage water-gas shift reactor receiving the cooled reformate gas from the heat exchanger, said second stage reactor including a catalyst that converts carbon monoxide and water to carbon dioxide and hydrogen, said second stage water-gas shift reactor being coupled to an outlet end of the heat exchanger by a second connector so that the first stage water-gas shift reactor, the heat exchanger and the second stage water-gas shift reactor are combined as a single unit.

2. The system according to claim 1 wherein the heat exchanger is selected from the group consisting of a tube and fin heat exchanger, a tube and shell heat exchanger and a bar and plate heat exchanger.

3. The system according to claim 1 wherein all of the catalysts are selected from the group consisting of precious metals, Fe_3O_4/Cr_2O_3 and CuO/ZnO.

4. The system according to claim 1 wherein the first and second stage reactors are medium temperature water/gas shift reactors that operate in the 300-400°C range.

5. The system according to claim 1 wherein the first stage reactor is a high temperature reactor operating in the 400-500°C range and the second stage reactor is a low temperature reactor operating in the 200-280°C range.

6. The system according to claim 1 wherein the water-gas shift reactor system is part of a fuel processing system for producing hydrogen for a fuel cell.

7. The system according to claim 6 wherein the water-gas shift reactor system is positioned between a primary reactor and a preferential oxidation reactor in the fuel processing system.

8 The system according to claim 1 wherein the reformate gas enters the first stage reactor at a temperature of about 300°C, enters the heat exchanger at a temperature of about 370°C, enters the second stage reactor at a temperature of about 310°C and exits the second stage reactor at a temperature of about 315°C.

9. The system according to claim 8 wherein the heat exchanger uses air, steam or liquid water to cool the reformate gas.

10. The system according to claim 9 wherein the air enters the heat exchanger at ambient temperature and exits the heat exchanger at about 360°C.

20. A fuel processing system for producing a hydrogen reformate gas, said system comprising:

a primary reactor, said primary reactor receiving a liquid hydrocarbon fuel and generating a reformate gas including hydrogen and carbon monoxide;

a first heat exchanger, said first heat exchanger receiving the reformate gas from the primary reactor and cooling the reformate gas;

a water-gas shift reactor assembly including a first stage water-gas shift reactor receiving the cooled reformate gas from the first heat exchanger, a second heat exchanger receiving the reformate gas from the first stage reactor, said second heat exchanger cooling the reformate gas, and a second stage water-gas shift reactor receiving the cooled reformate gas from the second heat exchanger, each of the first stage reactor, second heat exchanger and second stage reactor including a catalyst that converts carbon monoxide and water to carbon dioxide and hydrogen, said first stage water-gas shift reactor being coupled to an inlet end of the second heat exchanger by a connector and the second stage water-gas shift reactor being coupled to an outlet end

of the second heat exchanger by a connector so that the first stage water-gas shift reactor, the second heat exchanger and the second stage water-gas shift reactor are combined and the water-gas shift reactor assembly is a single unit;

a third heat exchanger, said third heat exchanger receiving the reformate gas from the second stage reactor and cooling the reformate gas; and

a preferential oxidation reactor, said preferential oxidation reactor receiving the cooled reformate gas from the third heat exchanger, said preferential oxidation reactor including a catalyst that selectively oxidizes carbon monoxide to carbon dioxide in the reformate gas.

21. The system according to claim 20 wherein one or both of the first and third heat exchangers include a catalyst that converts carbon monoxide and water to carbon dioxide and hydrogen.

22. The system according to claim 20 wherein the first, second and third heat exchangers are selected from the group consisting of tube and fin heat exchangers, bar and plate heat exchangers and tube and shell heat exchangers.

23. The system according to claim 20 wherein all of the catalysts are selected from the group consisting of precious metals, Fe_3O_4/Cr_2O_3 and CuO/ZnO.

EVIDENCE APPENDIX

There is no evidence pursuant to §1.130, §1.131 or §1.132.

RELATED PROCEEDINGS APPENDIX

There are no decisions rendered by a court or the Board in any proceeding identified in Section II of this Appeal Brief.